Age - size Characteristics of Fish Sampled from Ten Lakes in Southern New Brunswick in 1978

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AGE-SIZE CHARACTERISTICS OF FISH SAMPLED FROM TEN LAKES IN SOUTHERN NEW BRUNSWICK IN 1978

by

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ABSTRACT

Peterson, R. H., and D. J. Martin-Robichaud. 1983. Age-size characteristics of fish sampled from ten lakes in southern New Brunswick in 1978. Can. MS Rep. Fish. Aquat. Sci. 1723: iii + 32 p.

The age-size data of 23 species of fish collected from 10 N. B. lakes are presented. Where sufficient data were present, growth curves were calculated. Ages were determined by examination of scales or otoliths. Stickleback samples were not aged, but size-frequency histograms were derived. Recommendations are made for possible future surveys on these lakes which could improve the usefulness of the data for assessing effects of acidification.

Key words: length, age, brook trout, Atlantic salmon, rainbow smelt, chain pickerel, redbelly dace, fine scale dace, golden shiner, common shiner, lake chub, creek chub, blacknose shiner, fallfish, pearl dace, white sucker, brown bullhead, American eel, banded killifish, threespine stickleback, ninespine stickleback, white perch, pumpkinseed, smallmouth bass, yellow perch.

RÉSUMÉ

Peterson, R. H., and D. J. Martin-Robichaud. 1983. Age-size characteristics of fish sampled from ten lakes in southern New Brunswick in 1978. Can. MS Rep. Fish. Aquat. Sci. 1723: iii + 32 p.

Le rapport qui suit contient des données sur la taille par âge de 23 espèces de poissons capturés dans 10 lacs du Nouveau-Brunswick. Quand le volume de données le permet, on y inclut les courbes de croissance. Les écailles et les otolithes ont servi à la détermination des âges. L'âge des épinoches n'a pas été déterminé, mais on a produit des histogrammes de fréquence de tailles. Nous formulons des recommandations pour des relevés futurs de ces lacs, qui seraient de nature à rendre les données plus utiles dans l'évaluation des effects de l'acidification de l'eau.

INTRODUCTION

Fish reproduction and recruitment in lakes and streams have been found to be sensitive to acidification (Beamish et al. 1975; Leivestad et al. 1976). Missing year-classes or lack of recruitment of juveniles are among the symptoms of reproductive failure. It has also been shown that growth rates can vary in response to changes in water chemistry associated with acidification. For example, Ryan and Harvey (1980) demonstrated that the growth of juvenile yellow perch (ages 1-3) was greater in more acidic lakes, presumably due to lower densities. Older perch (6-8 yr), on the other hand, grew more slowly at lower pH. This report presents the analyses of age-length data of fish sampled from 10 southern N. B. lakes surveyed in the summer of 1978 to gain knowledge of the age structure and growth rates of these fish communities.

Possibly none of the lakes surveyed in this study was sufficiently acidic to affect fish recruitment and growth. However, two of the lakes (Mosquito and Robin Hood) have mean pH's less than 6.0 and Chisholm Lake has a pH near 6.0. Some knowledge of the fish populations of these lakes may serve as useful benchmarks should the lakes become more acidic in the future. However, it was not possible to obtain a satisfactory knowledge of fish population parameters from a survey, such as was performed in 1978 (Peterson 1980), when all species were sampled as the opportunity arose. Of the 23 species collected from the 10 lakes only the banded killifish (Fundulus diaphanus) collected from Creasey Lake, the ninespine stickleback Pungitius pungitius) from Chisholm Lake, white suckers (Catostomus commersoni from Mill, Mosquito and Mud Lakes, yellow perch (Perca flavescens) from Mill Lake, golden shiner (Notemigonus chrysoleucas) from Mud Lake, and white perch (Morone americanus) from Bolton and Wheaton Lakes were sufficiently extensive to obtain some insight into the age structure of the populations.

Some aspects of the fish collections (sites, net mesh sizes, effort, total numbers collected from the various lakes) have been presented in two previous reports (Peterson 1980; Peterson and Martin-Robichaud 1982).

METHODS

Fish were sampled three times throughout the summer. In most cases the data from the three fishings were combined, a procedure which will increase the scatter as size at a given age increases throughout the summer. This error will be greatest for the younger age groups where the percentage increase in length over a summer is greatest. In most cases the numbers are insufficent to correct for growth throughout the sampling period. In several situations, the data were so scanty that catches for a given species were combined from all lakes, and a "general" age-size relationship drawn. Considerably more data could have been generated had ages been back-calculated from scales and otoliths. This would have increased considerably the analytical time required. Scales and otoliths collected in the survey will be retained and are available should anyone wish to study them further, or check our interpretation.

The methods utilized in capturing the fish have been documented in the previous report (Peterson and Martin-Robichaud 1982). Scales were removed mid-way between the dorsal fin and lateral line, at the anterior end of the dorsal fin. Otoliths were removed from preserved fish in the laboratory, then stored dry in envelopes on which information regarding species, length, weight, lake, and date of capture were recorded. Scales were cleaned in a weak NaOH solution, rinsed in tap water, and viewed for analyses with a compound microscope. Large otoliths were broken, and cross-sections polished for ageing; small otoliths were observed whole. Initial polishing was done with "600" grit silicone carbide paper, and final polishing was applied with a "Gamal®" polishing cloth. The otoliths were then placed in a glycerine solution and viewed with a dissecting microscope. The otoliths were rotated or the light source manipulated until optimum lighting for viewing and counting annuli was established.

Fork lengths, rather than weights, were used in most analyses because they probably changed less due to shrinkage in fixative (10% formalin) prior to measurements (Van Oosten 1929; Hile 1936; Parker 1963). Both lengths and weights are given in the appropriate appendix.

Mean lengths and weights for each age group per species in individual lakes were calculated. When sufficient data were available, von Bertalanffy growth curves were fitted, using the equation $L_t = L\infty(1-e^{K(t-to)})$. The data were fitted by using an iterative process where K was the first term estimated. It was necessary to calculate the growth curves for lake chub, smallmouth bass, brown bullhead, fallfish and white sucker from data of all lakes combined. For yellow perch, golden shiner and white perch only data obtained from the lakes indicated were used. Inspection of data for inclusion in growth curves indicated that fish of a given year-class had grown little by June compared to the previous year-class in September. These fish were then included with the previous year-class for generation of the curve. The correct ages are given in the Tables and Appendices.

RESULTS

ATLANTIC SALMON (Salmo salar Linn.)

One landlocked salmon (22.1 cm) netted from Robin Hood Lake was aged 3 yr (Table 1) - greater than the mean length (18.7-20.5 cm) reported by Leggett and Power (1969) for age 3 landlocked salmon in two Newfoundland ponds, but lying within the range of values reported by these authors. The age was determined from scales.

BROOK TROUT (Salvelinus fontinalis (Mitch.))

Brook trout collected from Chisholm, Creasey, Kerr, Mill, Mosquito and Stein Lakes were combined for analyses. The age 2 year-class was most frequently collected (Fig. 1, App. 1) followed by ages 1 and 3. The growth curve fitted to the data is inaccurate for ages less than 1 due to insufficient sampling. Lengths at beginning of feeding would be near 2 cm (personal observation). The Stein Lake samples are unusual in that only large, age 3 fish were collected. Smith (1952) found the overall means of age 2, 3, or 4 brook trout from 8 lakes in the Bocabec and Chamcook catchments in southern New Brunswick to be 22.0, 29.1 and 32.4 cm, respectively (based upon 276, 584

and 140 specimens, respectively). These lengths are similar to those indicated in Fig. 1 for fish of comparable age.

RAINBOW SMELT (Osmerus mordax (Mitch.))

Two smelt specimens from Mill Lake were aged from otoliths. A "0" age specimen measured 1.7 cm in June and an 8.4-cm specimen was estimated to be age 1 (Table 1). These lengths are within the limits described by McKenzie (1958) for juvenile Miramichi smelts of equivalent age.

CHAIN PICKEREL (Esox niger Lesueur)

Three chain pickerel were collected from Bolton Lake (Table 1). The single 0 age fish had attained 13 cm by early August. The sizes at age are comparable to those listed in Scott and Crossman (1973) from Cassidy Lake. Chain pickerel ages were estimated by otoliths.

NORTHERN REDBELLY DACE (Phoxinus eos (Cope))

Most redbelly dace were collected from Creasey Lake. All fish sampled were aged from scales and determined to be either 0 or 1 (Table 1). The ages for the larger fish may be suspect as Scott and Crossman report somewhat older ages for dace of comparable size aged by using opercular bones. If this survey is performed again it would be advisable to collect opercular bones as well as scales.

FINESCALE DACE (Phoxinus neogaeus (Cope))

Two specimens of finescale dace were collected from Kerr Lake and both were assigned age 1 (Table 1). It is possible that the problems in ageing redbelly dace also apply to finescale dace.

LAKE CHUB (Couesius plumbeus (Agassiz))

Lake chub were collected in small numbers from 4 lakes, with Mill Lake yielding the most (11). The data suggest that few lake chub live beyond 3 yr, attaining a maximum length slightly over 12 cm (Fig. 2, App. 2), Twenty-two of the 26 fish collected were aged 1 and 2. The single 0 age fish collected was 3.8 cm in early August. Smith (1952) considered age 1 lake chub to have attained a mean length of 8-9 cm in Gibson Lake in October.

GOLDEN SHINER (Notemigonus crysoleucas (Mitchill))

Most golden shiners were sampled from Mud Lake, with a few specimens from Bolton and Mill Lakes. Age 2 and 3 golden shiners were the year-classes overwhelmingly represented in the Mud Lake samples (Fig. 3, 4A, App. 3). The Mud Lake golden shiners attain a length of about 10 cm at the end of the 3rd summer (age 2), 12-13 cm at age 3 and 14-15 cm at age 4. Lengths at age are very similar to those reported by Cooper (1936) for Michigan golden shiners.

COMMON SHINER (Notropis cornutus (Mitchill))

Most common shiners were seined from Bolton Lake. The data (Table 2) indicate that age 0 common shiners attain a length of about 6 cm by the end of their first summer. Age 1 fish attain 8-12 cm and age 2 fish 10-12 cm by summer's end.

BLACKNOSE SHINER (Notropis heterolepis Eigenmann & Eigenmann)

Blacknose shiners were sampled from Kerr Lake. All were 3.8-4.4 cm and were judged to be age 1 (Table 1). However, ageing of these specimens, by scales, was not completely satisfactory. In particular, the September specimens may have been age 2. Future ageing should utilize other structures, perhaps opercular bones, as well as scales.

CREEK CHUB (Semotilus atromaculatus (Mitchill))

Three creek chub were aged (Table 1) with the 7.7-cm specimen from Mill Lake classified as age 0 (possible 1) and the two larger fish as age 2.

FALLFISH (Semotilus corporalis (Mitchill))

A total of 41 fallfish were aged from Bolton, Mill, Mud and Robin Hood Lakes (Table 3). A generalized growth pattern was developed by combining the fallfish from all lakes (Fig. 5). Fallfish from Robin Hood Lake - the most acidic lake where fallfish were collected - appeared smaller at a given age than those from Mill or Mud Lakes (Table 3). The age 3 specimens from Robin Hood Lake were 13.0-15.8 cm (n=6) while those from Mud Lake were 22-24 cm (n=2).

PEARL DACE (Semotilus margarita (Cope))

One series of pearl dace was taken from Mill Lake in August (Table 1). The 0 age fish averaged 4.6 cm in length and the age 1 fish 7.1 cm. In comparison, Loch (1969 (in Scott and Crossman 1973)) suggested age 1 fish to be 5.5-6.5 cm and age 2 fish to be 7.5-9.5 cm for some Ontario populations.

WHITE SUCKER (Catostomus commersoni (Lacépède))

White suckers were collected from Bolton, Kerr, Creasey, Mill, Mosquito, Mud, and Robin Hood Lakes, with the largest collections from Mill, Mosquito, Mud and Robin Hood. Age 3 fish dominated the gillnet catches in these lakes as demonstrated by the age-frequency histograms (Fig. 6, App. 4). Small suckers were probably not netted as efficiently, and the nets were probably not set deeply enough to catch the larger suckers. By the end of their first summer, white suckers in these lakes attained a length of 4-6 cm, 8-10 cm by age 1 or 2nd summer and 16-19 cm by the end of the 3rd summer. The numbers collected were too small to reveal any differences in sucker growth among the various lakes surveyed. The growth curve (Fig. 7) again indicates that the largest suckers were not collected as there is no indication of the growth leveling off. The generalized growth pattern (Fig. 7) indicates that growth is somewhat greater than given by Smith (1952) for Gibson Lake, but is still lower than those given for Ontario localities (Scott and Crossman 1973). Growth curves given in Fig. 7 resemble those for George and South Pine Lakes (Beamish 1973) where there is rapid increase in length during the first 4-5 yr.

Difficulties in ageing suckers by examination of scales are known to exist (Beamish and Harvey 1969). These difficulties are reported mainly for fish older than 5 yr, which were few in these

collections. It is suggested that, if future surveys are carried out, fin rays be collected also to check on the scale determinations.

BROWN BULLHEAD (Ictalurus nebolasus (Lesueur))

Brown bullheads were captured from Mill Lake, and particularly from Mud Lake (Fig. 8, App. 5). The length-age relationship for Mud Lake bullheads (Fig. 8) indicates a somewhat slower growth rate than those reported by Priegel (1966) for a northern Wisconsin collection (24.1 cm at age 4, 26.7 cm at age 5). Most of the bullheads collected were ages 2-4.

AMERICAN EEL (Anguilla rostrata (Lesueur))

Only 3 eels were sampled in the survey, and the inadequacy of the sampling methods for collecting eels has been noted previously (Peterson and Martin-Robichaud 1982). The ages of the two larger eels collected were not determined (Table 1), and the small eel was determined to be age 0.

BANDED KILLIFISH (Fundulus diaphanus (Lesueur))

The largest collections of killifish were from Bolton (Fig. 9), Creasey (Fig. 10), Wheaton (Fig. 11), and Robin Hood (Fig. 12) Lakes. Fewer were collected from Stein, Mosquito, Mill, and Kerr Lakes (App. 6a). In all lakes the June samples were mainly age 1 and 2 fish with a few age 3 (Fig. 9-12). A large component of 0 age fish was present in most August and September collections, as well as in the late July collection from Bolton Lake in 1977. No age 3 fish were collected later than June. By the end of the 1st, 2nd and 3rd summers, Creasey Lake killifish attained mean lengths of 3, 6, and 7.6 cm, respectively (Fig. 10). These values appear typical for most of the other lakes sampled. Wheaton Lake killifish, however, appear to grow more rapidly with mean lengths of 3.9, 7.8, and 10.2 cm attained at the end of the 1st, 2nd, and 3rd summers, respectively (Fig. 11). The largest killifish sampled was from Wheaton Lake in June at 11.0 cm (age 3). Mortality appears to be great in the age 2 and 3 classes, as age 2 fish are relatively scarce, and only a few age 3 fish were collected in the June sampling.

THREESPINE STICKLEBACK (Gasterosteus aculeatus Linn.)

Otoliths were not recovered from the threespine sticklebacks sampled from Mill Lake (Fig. 13, App. 6b). A hypothetical interpretation of the length-frequency distributions (Fig. 14) would be that the larger sticklebacks sampled in June are age 1 (and possibly age 2) and that the smaller ones sampled in August represent the current year's recruitment. This interpretation agrees generally with the ageing study of Jones and Hynes (1950).

NINESPINE STICKLEBACK (Pungitius pungitius (Linn.))

As with the threespine stickleback, otoliths were not recovered in sufficient numbers to properly age this species. The length-frequency histograms resemble those for the threespine stickleback. Large numbers of smaller fish were collected in the August seinings (Fig. 14-16); the modal length for these smaller fish ranged from 2.3 cm for Robin Hood Lake to 3.0 cm for Mosquito Lake sticklebacks. By late September the modal length for these presumed age 0 fish had increased to 3.2 and 3.5 cm for Robin Hood and Chisholm Lakes, respectively. The June peak at 3.5 cm shown in the Robin Hood Lake and Chisholm Lake histograms probably represents the age 1 category; the larger sticklebacks of the June seining in Mosquito Lake, with a mean length near 5.0 cm, may represent age 2 sticklebacks. The Chisholm Lake distributions are skewed toward greater lengths, and the fish contributing to this skewed distribution probably represent age 2 and 3 fish. The largest fish collected in the June seining of Chisholm Lake (ca 5.0 cm) may include a few age 3 fish still surviving.

WHITE PERCH (Morone americanus (Gmelin))

Large collections of white perch were obtained from Bolton and Wheaton Lakes. The age structure of the samples taken from the two lakes is similar with ages 5-10 well represented (Fig. 17, App. 7). Fish older than 10 yr decrease in numbers, possibly reflecting increased mortality of these older fish. Age 2 fish (12-14 cm) are probably not gillnetted efficiently, or may not occupy the same habitat as older fish. It would seem that neither population is exploited to any degree. The growth curves (Fig. 18, 19) indicate that most individuals do not surpass a length of 22 cm. A length of 4-6 cm is attained by the end of the 1st summer, 10-12 cm at the end of the 2nd, 12-15 cm by the 3rd and 14-16 cm by the end of age 3. These sizes at age are larger than determined by Smith (1939) for Lake Jesse, N. S., but less than those found for white perch in Lake Ontario and Oneida Lake (Sheri and Power 1968; Scott and Crossman 1973). The 16-yr-old perch recorded here may be a new longevity record as Scott and Crossman (1973) report a 17-yr-old as the oldest (from Maine in 1941).

Since the white perch populations included many old fish, it was decided to age them both by scales and by otoliths. The ages obtained by the two methods (Fig. 20) indicate little difference up to age 6 at which point otolith ages tend to yield greater ages on the average. The discrepancy may be several years for some fish. All ages used in the analyses described here are based on otoliths.

PUMPKINSEED (Lepomis gibbosus (Linnaeus))

Pumpkinseeds were sampled from Kerr, Mill, Mud and Robin Hood Lakes. Age 0 fish attain a length of 2-3 cm by late summer (Fig. 21) with age 1, 2, and 3 attaining lengths of 8-9, 12-13 and 13-14 cm, respectively. It is difficult to compare the growth rate for these pumpkinseeds (most from Mud Lake - App. 8) with those recorded by Reid (1930) for Welch and Gibson Lakes as the latter report is based on standard lengths as opposed to fork lengths for our data. It would appear that the growth rates are not too dissimilar.

SMALLMOUTH BASS (Micropterus dolomieui (Lacépède))

Smallmouth bass were netted from 5 lakes with Mud Lake yielding the largest numbers. The data suggest that the usual maximal length for this species is about 40 cm at which time they are 8-10 yr of age (Fig. 22, App. 9). Of the 12 bass gillnetted from Mud Lake, 8 were 7-9 yr of age with lengths of 33-38 cm. The age-size relationships described here are very similar to those presented by Smith (1942) for Potter's Lake, N. B.

YELLOW PERCH (Perca flavescens (Mitchill))

Yellow perch were also aged both by scales and by otoliths. The scale ages were consistently 1-2 yr older than the otolith ages (Fig. 23) with a tendency toward some convergence at the older ages. Scale ages were utilized in constructing the growth curve, as these seemed more reasonable for the lower age classes when compared with sizes (App. 10). Perch younger than age 2 were not aged by otoliths.

Most yellow perch collections were made from Mill Lake, with some juveniles taken from Bolton Lake by beach seines. The growth curve is undoubtedly not representative of the population growth pattern (Fig. 24). Inadequate numbers of older fish biased the estimate of maximum length. Possibly there is some repression of growth for ages 0-4. The age 3 and age 6 year-classes were dominant in the Mill L. yellow perch collections (Fig. 48). Perch begin feeding more heavily on other fish at a length of about 15 cm (age 5-6) (Peterson and Martin-Robichaud 1982). The size-age relationships for Mill Lake perch indicate that growth is more rapid than that published by Smith (1952) for yellow perch from Bonaparte and Johnson Lakes as well as those for Lake Jesse, N. S. (Smith 1939). The growth, however, is less than that determined for Great Lake populations (Jobes 1951). Female yellow perch have frequently been found to grow more rapidly than do males (Jobes 1951; Le Cren et al. 1977). The fish from this survey were not sexed, so the growth data are a composition of both sexes. Jobes (1951) found that females lived longer and grew faster after age 2. If the larger fish of our collection were primarily females, then this would also be a factor in determining the shape of the curve and result in less "flattening" of the curve at older ages.

DISCUSSION

One of the most obvious ways in which acidification affects fish populations is through reproductive failure, resulting in the absence of year-classes in the population (Beamish et al. 1975; Leivestad et al. 1976). Growth rates are influenced in somewhat unpredictable ways, and can be related secondarily to acidification through removal of competitors or decreases in population size. Hence, increased growth rate as a result of lake acidification has been documented (e.g. Ryan and Harvey 1980). Much of the data presented here is too scanty to permit any conclusions as to growth rates or presence-absence of year-classes. Combining data for several lakes would also obscure pH effects, if present. The data for such species as landlocked Atlantic salmon, rainbow smelt, and chain pickerel have little more value than to serve as an indication of the presence of the species in a given lake.

In a few instances the data are complete enough that one can say with some confidence that all age classes are present and the growth rates are probably fairly representative of the population. Examples are the white suckers of Bolton and Mill Lakes, banded killifish of Creasey, Wheaton, Bolton and Robin Hood Lakes, white perch of Wheaton and Bolton Lakes, yellow perch of Mill Lake, and possibly the ninespine sticklebacks of Chisholm Lake. It seems improbable that any of the data given on these populations are indicative of any problems related to acidification.

It is suggested that, if the survey is repeated in 1988, more effort be put into establishing whether or not reproduction has been successful for the past 2-3 yr. This may require electrofishing some of the streams feeding or draining the lakes to assess reproduction of such species as brook trout and landlocked salmon. It would also be useful to employ rotenoning techniques to limited areas of shoreline. This procedure was effective when used in Mud Lake for juvenile smallmouth bass. This method would allow more shoreline habitats to be sampled in addition to those easily seined. A larger size range of gillnet meshes would also be desirable as well as the use of other collecting gear, such as otter trawls.

Particular instances where more intensive sampling might reveal stresses due to acidification are the fallfish, landlocked salmon and rainbow smelt populations of Robin Hood Lake and the brook trout population of Chisholm and Mosquito Lakes.

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REFERENCES

Beamish, R. J. 1973. Determination of age and growth of populations of the white sucker (Catostomus commersoni) exhibiting a wide range in size at maturity. J. Fish. Res. Board Can. 30: 607-616.

Beamish, R. J., W. L. Lockhart, J. C. van Loon, and H. H. Harvey. 1975. Long-term acidification of a lake and resulting effects on fishes. Ambio 4: 98-102.

Beamish, R. J., and H. H. Harvey. 1969. Age determination in the white sucker. J. Fish. Res. Board Can. 26: 633-638.

Cooper, G. P. 1936. Age and growth of the golden shiner (Notemigonus crysoleucas amatus) and its suitability for propagation. Pop. Mich. Acad. Sci. Arts Lett. 21: 587-597.

Hile, R. 1936. Age and growth of Cisco, Leucichthys artedi (LeSueur), in the lakes of Northeastern Highlands, Wisconsin. Bull. U.S. Bur. Fish. 48: 211-317 (Bull. No. 19).

Jobes, F. W. 1951. Age, growth and reproduction of yellow perch in Lake Erie. Fish. Bull. U. S. Fish and Wildlife Serv. 52: 205-266.

Jones, J. W. and H. B. N. Hynes. 1950. The age and growth of Gasterosteus aculeatus, Pygosteus pungitius, and Spinachia vulgaris, as shown by their otoliths. J. Anim. Ecol. 19: 59-73.

Le Cren, E. D., C. Kipling, and J. C. McCormack. 1977. A study of the numbers, biomass and year class strengths of perch (Perca flavescens L.) in Windermere from 1941 to 1966. J. Anim. Ecol. 46: 281-307.

Leggett, W. C., and G. Power. 1969. Differences between two populations of landlocked Atlantic salmon (Salmo salar) in Newfoundland. J. Fish. Res. Board Can. 26: 1585-1596.

Leivestad, H., G. Hendrey, I. P. Muniz, and E. Snekvik. 1976. Effects of acid precipitation on freshwater organisms, p. 87-111. In Impact of Acid Precipitation in Forest and Freshwater Ecosystems in Norway (ed. F. H. Brakke). SNSF Res. Rep. 6 p.

McKenzie, R. A. 1958. Age and growth of smelt, Osmerus mordax (Mitch.), of the Miramichi River, New Brunswick. J. Fish. Res. Board Can. 15: 1313-1327.

Parker, R. R. 1963. Effects of formalin on length and weights of fishes. J. Fish. Res. Board Can. 20: 1441-1455.

Peterson, R. H. 1980. Water chemistry of ten lakes in southern New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 962: 25 p.

Peterson, R. H., and D. J. Martin-Robichaud. 1982. Food habits of fishes in ten New Brunswick lakes. Can. Tech. Rep. Fish. Aquat. Sci. 104: 43 p.

Priegel, G. R. 1966. Age-length and length-weight relationship of bullheads from Little Lake, Butte des Mortes, 1959. Wis. Conserv. Dep. Res. Rep. Fish. 17: 6 p.

Reid, H. 1930. A study of Eupomotis gibbosus (L.) as occurring in the Chamcook Lakes, N.B. Contrib. Can. Biol. Fish. 5: 457-466.

Ryan, P. M., and H. H. Harvey. 1980. Growth responses of yellow perch Perca flavescens (Mitchill) to lake acidification in the LaCloche Mountain Lakes of Ontario. Environ. Biol. Fishes 5: 97-108.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184: 966 p.

Sheri, A. N., and G. Power. 1968. Reproduction of white perch, Roccus americanus, in the Bay of Quinte, Lake Ontario. J. Fish. Res. Board Can. 25: 2225-2231.

Smith, M. W. 1952. Limnology and trout angling in Charlotte County lakes, New Brunswick. J. Fish. Res. Board Can. 8: 383-452.

_____ 1942. The smallmouth black bass in the Maritime Provinces. Fish. Res. Board Can. Progr. Rep. Atl. 32: 3-4.

_____ 1939. The fish population of Lake Jesse, Nova Scotia. Proc. Nova Scotian Inst. Sci. 19: 389-427.

Van Oosten, J. 1929. Life history of the lake herring (Leucichthys artedi (LeSueur) of Lake Huron as revealed by its scales, with a critique of the scale method. Bull. U.S. Bur. Fish. 44: 265-428 (Doc. #1053).

Table 1. Ages, lengths and weights of 8 species of fish for 10 N. B. lakes.

Date	Lake	$\bar{L}$ength (cm)	Range or SD	$\bar{W}$t (g)	Range or SD	n	Age (yr)
		Chain pickerel (aged from otoliths)					
13.06.78	Bolton	54.0	-	1276.2	-	1	5
10.08.78	"	34.5	-	305.4	-	1	2
09.08.78	"	13.0	-	14.1	-	1	0
		Rainbow smelt (aged from scales)					
13.06.78	Mill	1.7	-	0.1	-	1	0
25.09.78	"	8.4	-	4.4	-	1	1
		Finescale dace (aged from scales)					
09.08.78	Kerr	5.2	5.2-5.3	1.65	1.6-1.7	2	1
		Atlantic salmon (aged from scales)					
14.08.78	Robin Hood	22.1	-	124.8	-	1	3
		American eel (aged from otoliths)					
09.08.78	Wheaton	14.3	-	4.5	-	1	0
		Creek chub (aged from scales)					
10.08.78	Mill	7.7	-	5.3	-	1	0
14.08.78	Mosquito	16.0	-	50.4	-	1	2
14.08.78	Robin Hood	12.5	-	25.2	-	1	2
		Blacknose shiner (aged from scales)					
12.06.78	Kerr	3.8	1.0	0.6	0.34	7	1
09.08.78	"	4.1	-	0.8	-	1	1
22.09.78	"	4.4	-	1.0	-	2	1 or 2
		Pearl dace (aged from scales)					
10.08.78	Mill	4.6	0.44	1.1	0.27	7	0
10.08.78	"	7.1	0.3	4.5	0.62	11	1

Table 2. Age-size data for redbelly dace collected from 3 lakes.

Lake	Date	$\bar{L}$	SD	$\bar{W}$t	SD	n	Age
Creasey	26.07.77	5.3		2.0		13	1
	09.09.78	5.2		1.4		1	1
	22.09.78	2.3		0.1		7	0
		3.7		0.6		1	1
Mosquito	15.08.78	5.2		1.5		1	1
Robin Hood	14.08.78	1.5		0.03		2	0
		2.2		0.2		1	1

Table 3. Age-size data for common shiners (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	N
				Bolton Lake				
12.06.78	1	6.6	0.058	6.5-6.6	3.3	0.058	2.6-4.0	3
	2	7.8	0.65	6.6-9.6	6.1	0.65	4.0-10.2	19
09.08.78	0	6.3		-	3.5		-	1
	1	9.6		7.8-10.5	11.9		5.8-17.6	100
	2	11.0		10.5-11.8	18.4		16.4-22.8	11
				Kerr Lake				
12.01.78	1	6.0		4.5-7.3	2.4		0.8-4.1	3

Table 4. Age-size data for fallfish samples (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	N
				Bolton Lake				
12.06.78	2	9.5		9.3-9.8	10.3		10.0-10.6	3
13.06.78	4	22.7		-	147.8		-	1
09.08.78	0	3.7		-	0.7		-	1
10.08.78	3	16.7		-	58.1		-	1
29.09.78	3	22.4		21.8-23.0	146.2		136.0-156.4	2
	4	22.5		-	149.6		-	1
				Mill Lake				
26.09.78	2	15.5		14.8-16.6	48.3		42.6-58.9	3
				Mud Lake				
06.06.78	-	12.5		-	20.0		-	1
29.09.78	3	22.3		-	148.9		-	1
	3	24.1		-	188.1		-	1
				Robin Hood Lake				
15.06.78	2	12.7		11.8-13.5	22.1		18.9-27.8	7
	3	14.4		13.0-16.1	37.5		21.4-49.2	5
	4	15.4		15.4-15.5	53.2		48.6-57.7	2
	5	21.7		20.0-23.7	149.7		96.6-221.4	3
26.09.78	2	15.0		14.2-15.7	42.2		37.0-47.6	3
	3	15.8		-	48.4		-	1
	4	19.1		16.9-20.3	98.0		59.4-124.3	3
	5	21.8		21.1-22.2	136.2		128.8-145.3	3
				Supplementary Data				
				Bolton Lake				
25.07.78	2	10.8		9.2-12.5	21.2		(18.7-23.7)	2
	1	5.0			1.6			1
	0	2.1			0.2			1

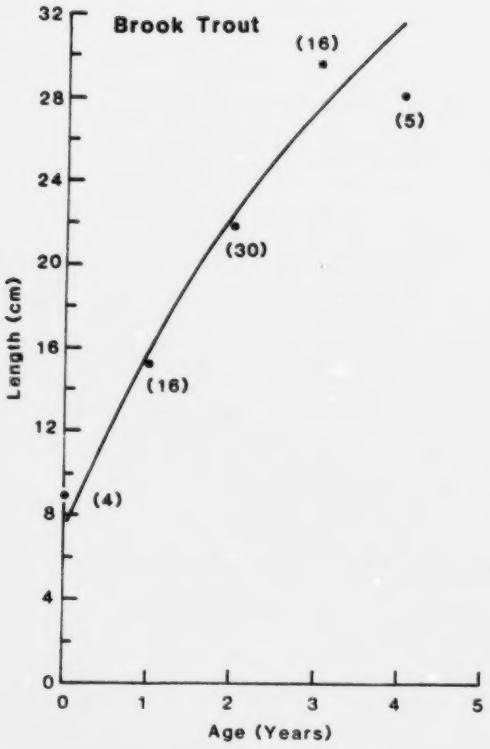

Fig. 1. Length-age curve generated for brook trout collected (all lakes combined). The von Bertalanffy equation of best fit is:

$$\ell_t = 47.13\ [1-e^{-0.23(t-(-0.74))}].$$

Numbers in parentheses are numbers of fish collected for each age.

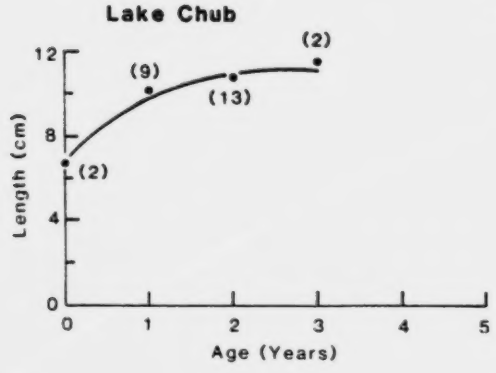

Fig. 2. Length-age curve generated for lake chub collected (all lakes combined); line fitted by eye. Numbers in parentheses are numbers of each age-class collected.

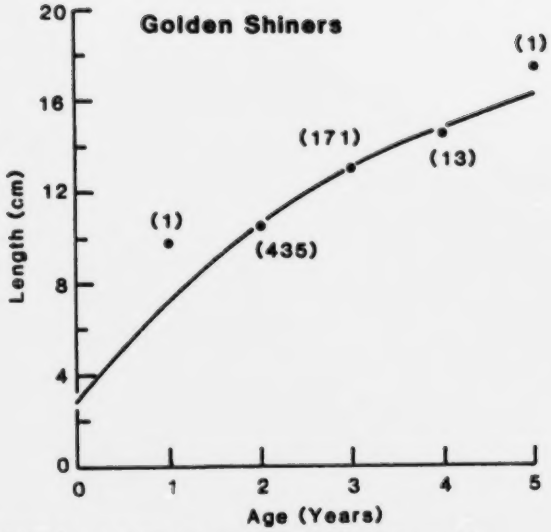

Fig. 3. Length-age curve generated for golden shiners collected (Mud Lake). The von Bertalanffy equation of best fit is:

$$\ell_t = 20.46\ [1-e^{-0.28(t-(-0.56))}].$$

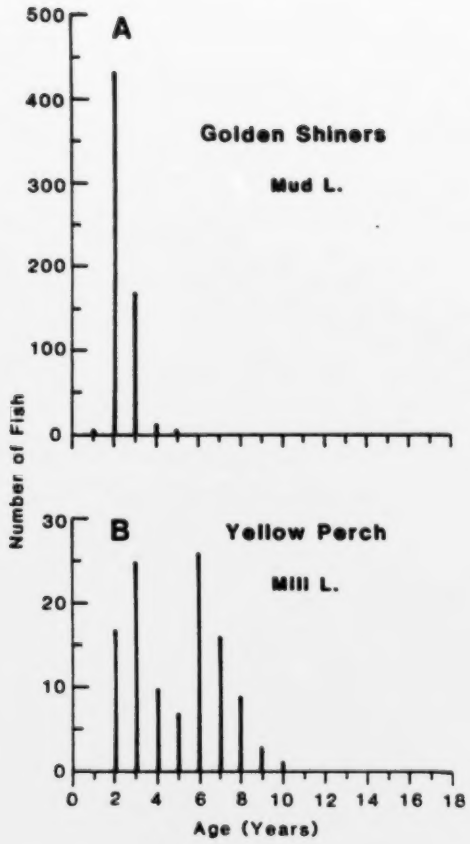

Fig. 4A. Frequency histogram of age-classes of golden shiners collected from Mud Lake by gillnet.

Fig. 4B. Frequency histogram of age-classes of yellow perch collected from Mill Lake by gillnet.

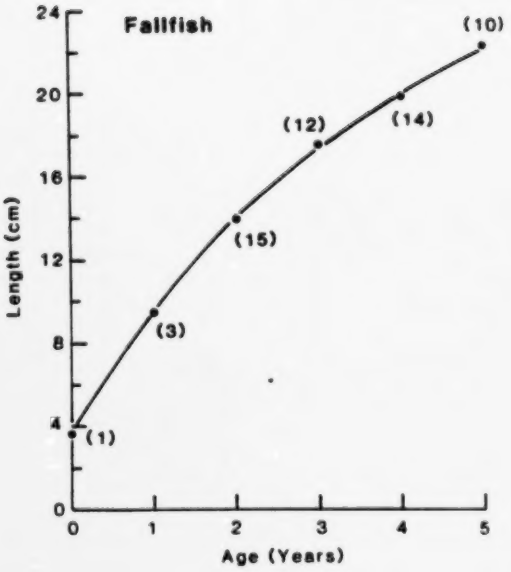

Fig. 5. Length-age curve generated from fallfish collected (all lakes combined). The von Bertalanffy equation of best fit is:

$$\ell_t = 29.38\ [1-e^{-0.25(t-(0.55))}].$$

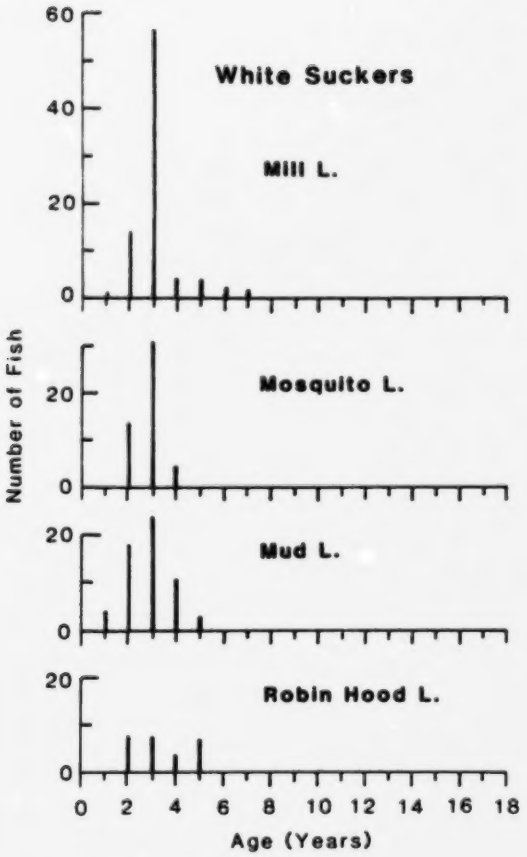

Fig. 6. Frequency histograms for various year-classes of white suckers from lakes indicated in the figure.

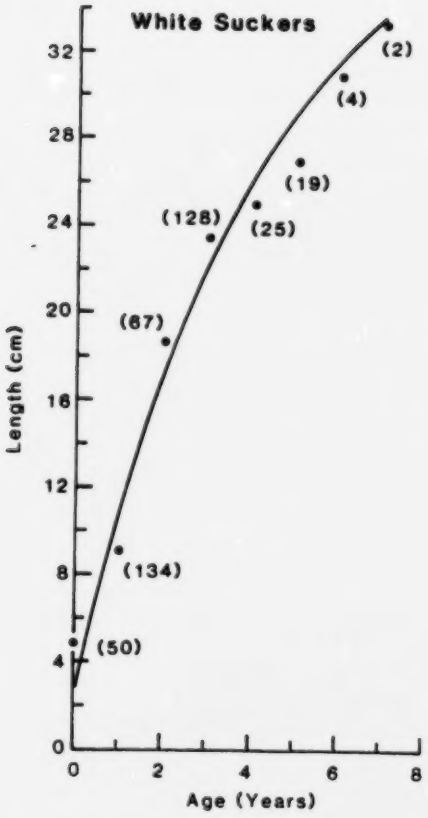

Fig. 7. Length-age curve generated for white suckers collected (all lakes combined). The von Bertalanffy equation of best fit is:

$$\ell_t = 40.72\ [1-e^{-0.24(t-(-0.31))}].$$

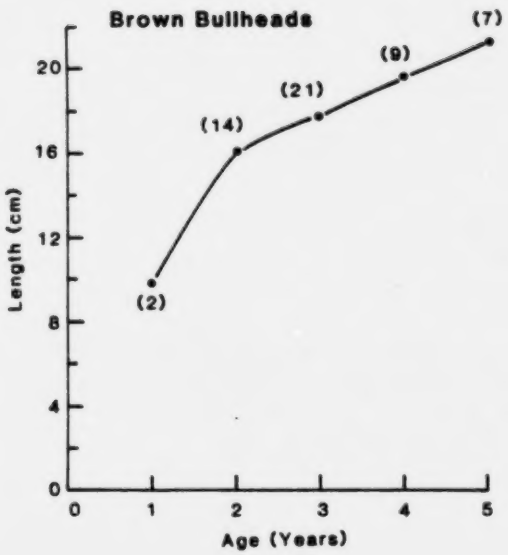

Fig. 8. Length-age curve for brown bullheads collected from Mud Lake. The line is fitted by eye.

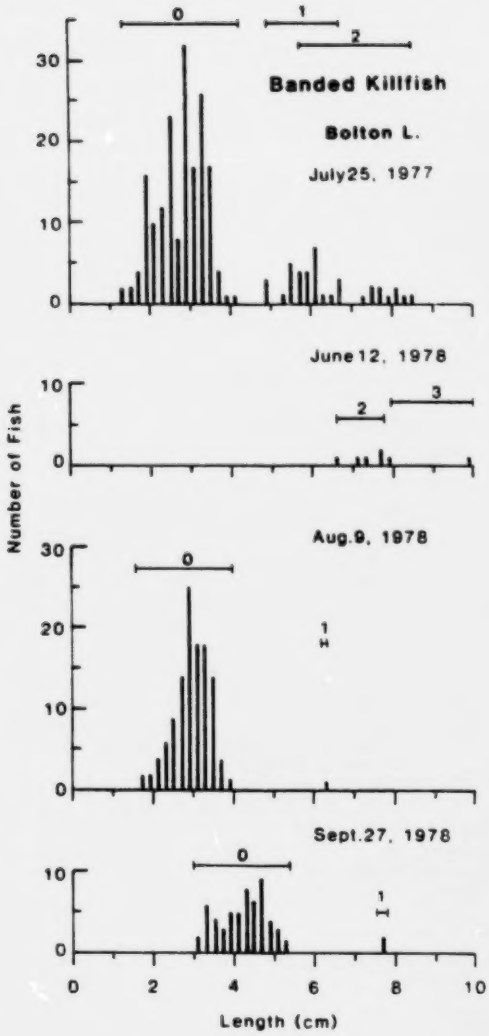

Fig. 9. Frequency histograms of banded killifish of various lengths for Bolton Lake. Horizontal bars indicate the length spread for fish of a given age.

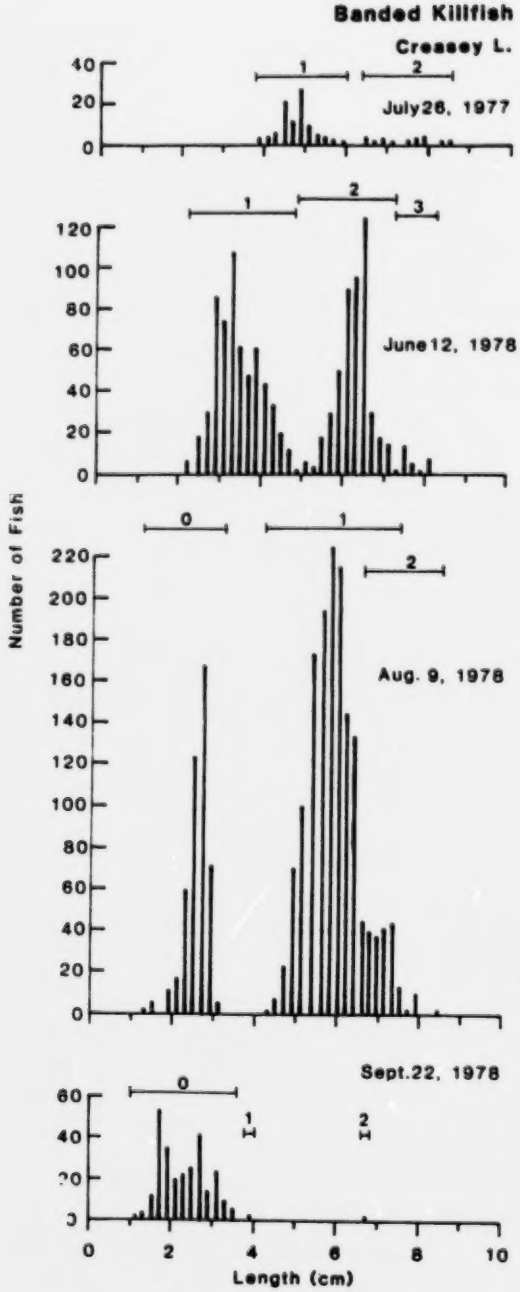

Fig. 10. Frequency histograms for banded killifish of various lengths collected from Creasey Lake; details as for Fig. 9.

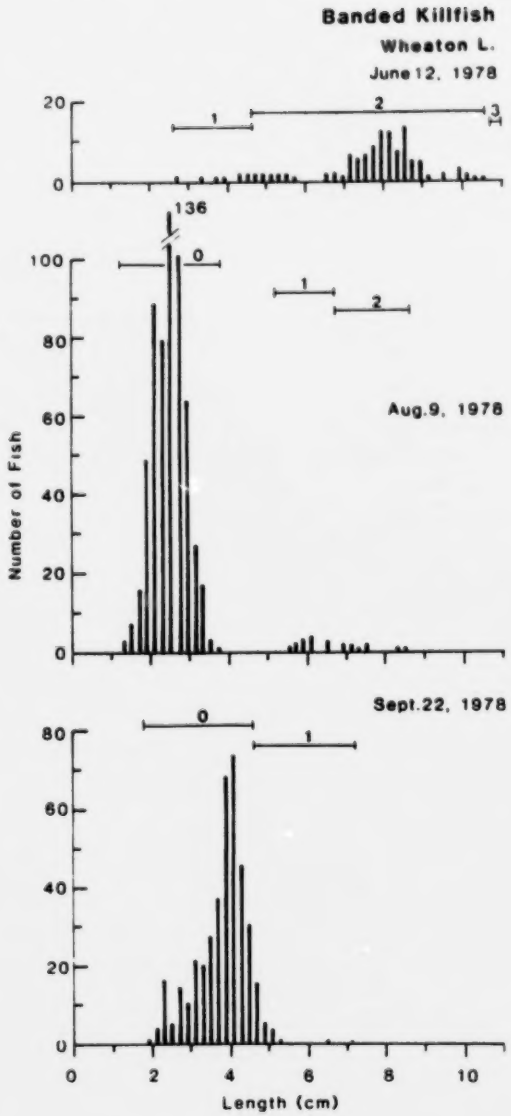

Fig. 11. Frequency histograms for banded killifish of various lengths collected from Wheaton Lake; details as for Fig. 9.

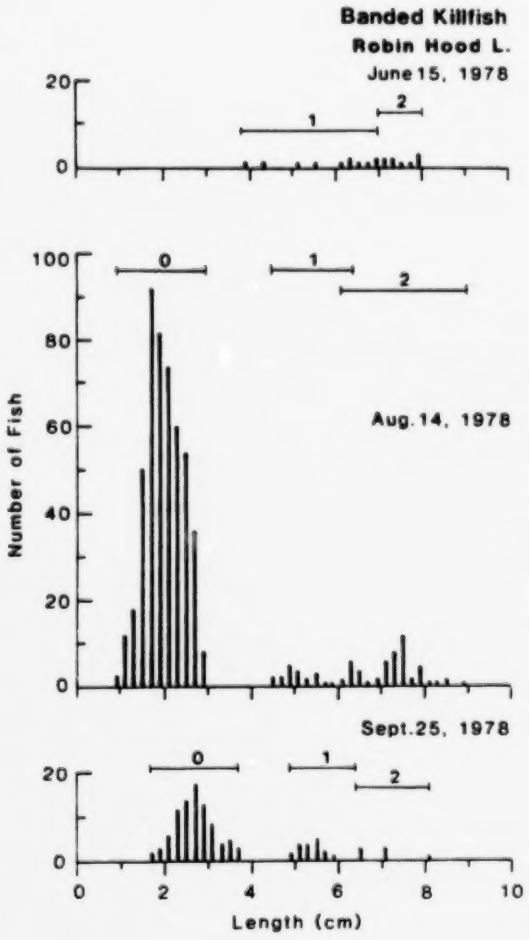

Fig. 12. Frequency histograms for banded killifish of various lengths collected from Robin Hood Lake; details as for Fig. 9.

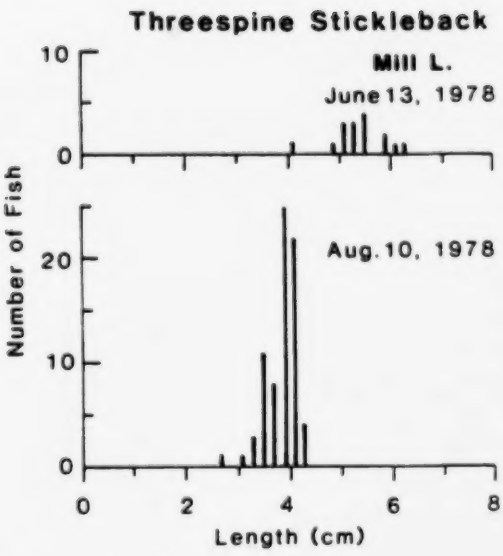

Fig. 13. Length-frequency histograms of threespine sticklebacks collected from Mill Lake in June and August.

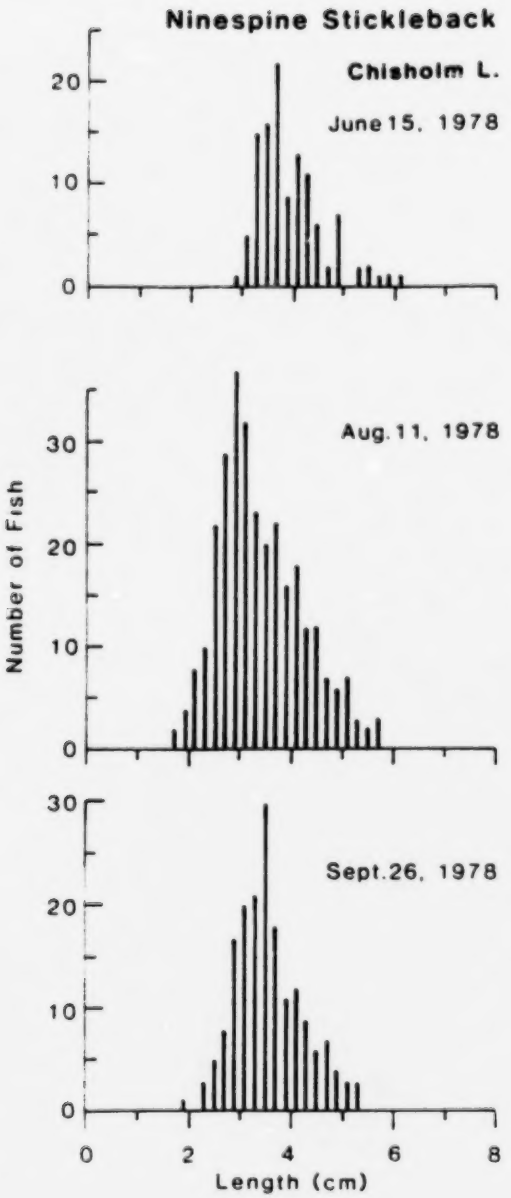

Fig. 14. Length-frequency histograms of ninespine sticklebacks collected from Chisholm Lake.

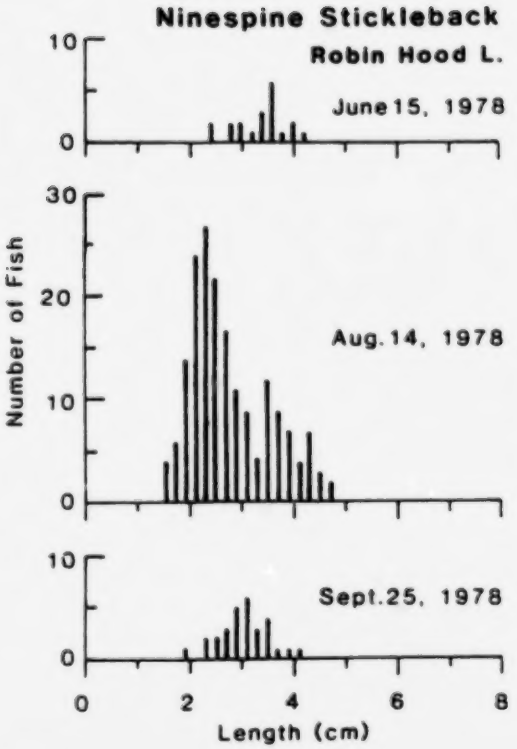

Fig. 15. Length-frequency histograms of ninespine sticklebacks collected from Robin Hood Lake.

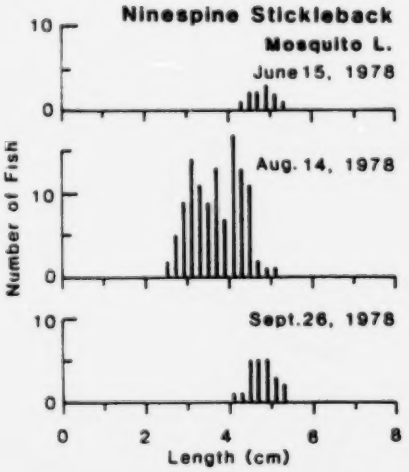

Fig. 16. Length-frequency histograms of ninespine sticklebacks collected from Mosquito Lake.

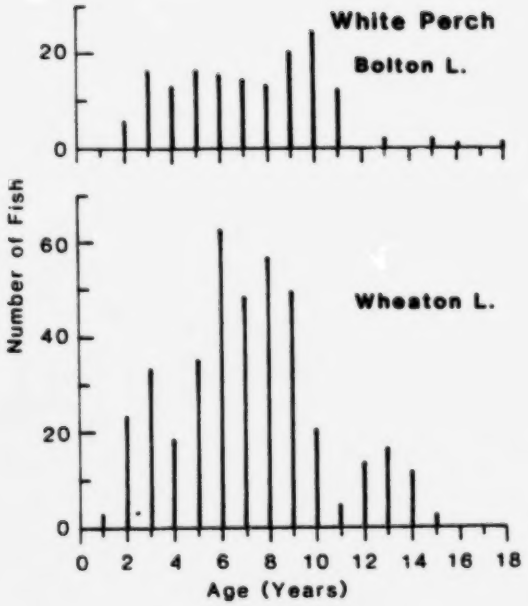

Fig. 17. Age-frequency histograms of white perch collected from Bolton and Wheaton Lakes by gillnet.

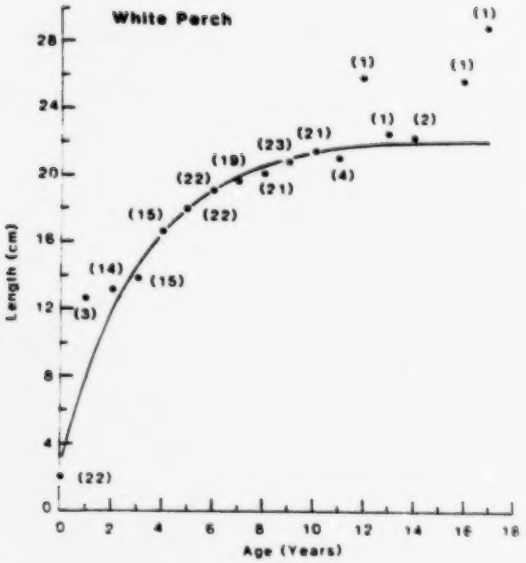

Fig. 18. Length-age curve generated for white perch collected from Bolton Lake. The von Bertalanffy equation of best fit is:

$$l_t = 22.23\ [1-e^{-0.32(t-(-0.40))}].$$

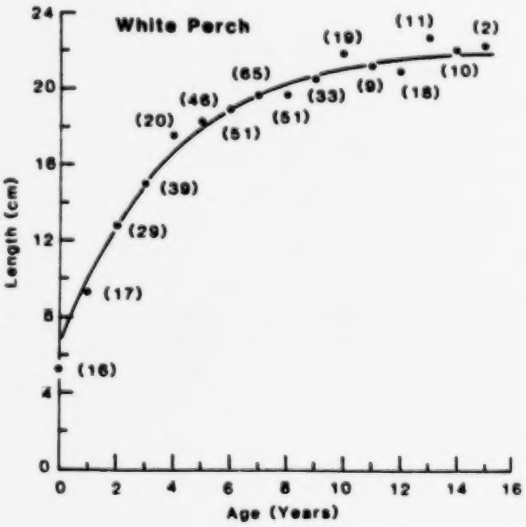

Fig. 19. Length-age curve generated from white perch collected from Wheaton Lake. The von Bertalanffy equation of best fit is:

$$l_t = 22.37\ [1-e^{-0.25(t-(-1.40))}].$$

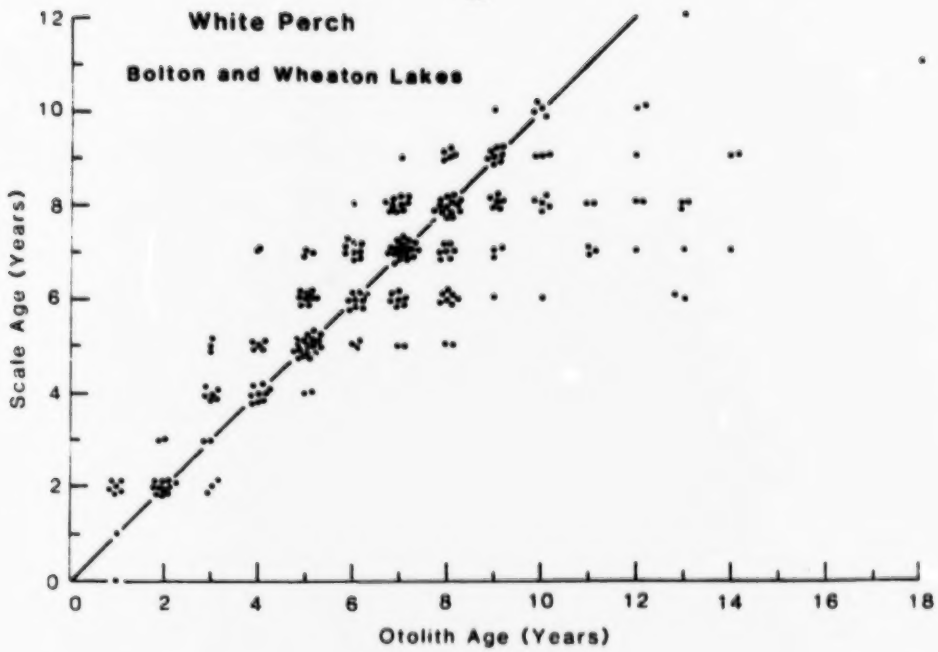

Fig. 20. Ages of white perch from Bolton and Wheaton Lakes (combined) as determined from scales versus ages as determined from otoliths. The line of equality (angle of 45°) is drawn.

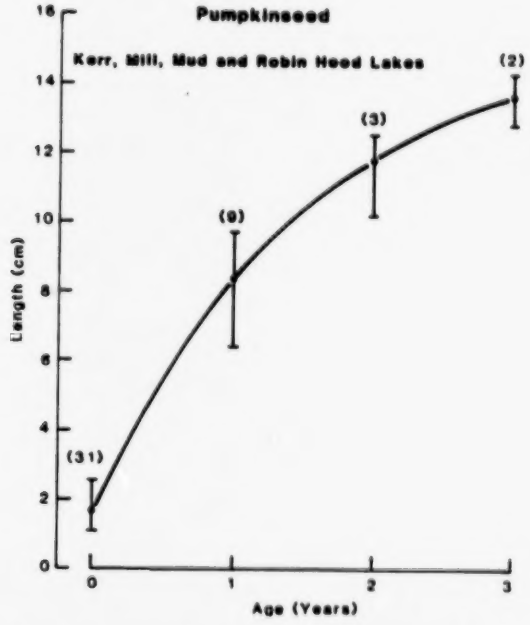

Fig. 21. Length-age curve for pumpkinseeds collected from 4 lakes (combined). The curve is fitted by eye. Number of fish represented by each point is given in parentheses.

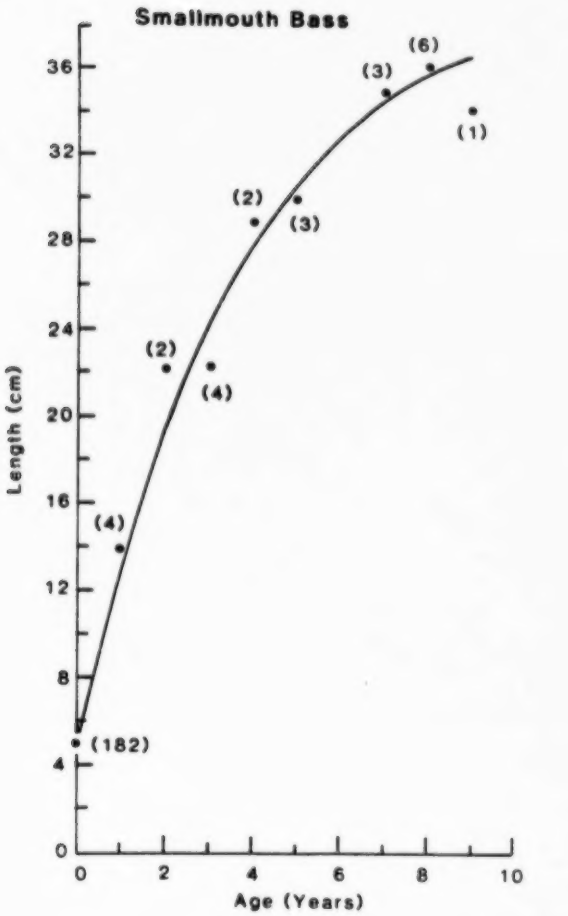

Fig. 22. Length-age curve generated for smallmouth bass collected (all lakes combined). The von Bertalanffy equation of best fit is:

$$l_t = 39.68\ [1-e^{-0.27(t-(-0.50))}].$$

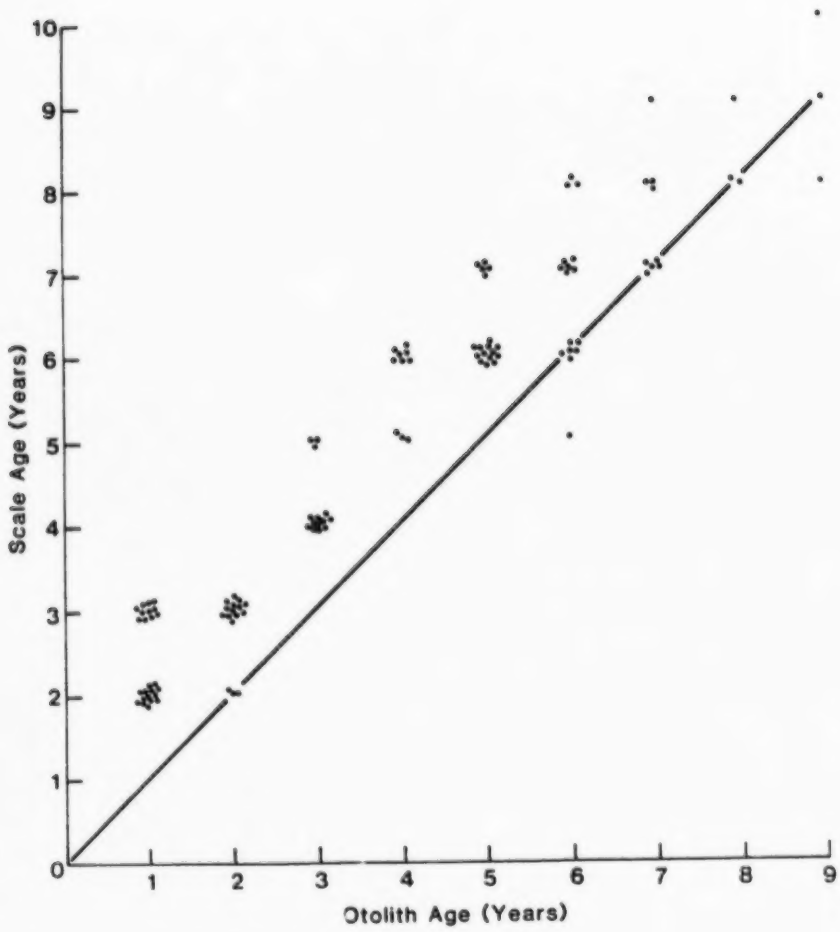

Fig. 23. Ages of yellow perch from Mill Lake determined from scales versus ages as determined by otoliths; the line of equality is drawn.

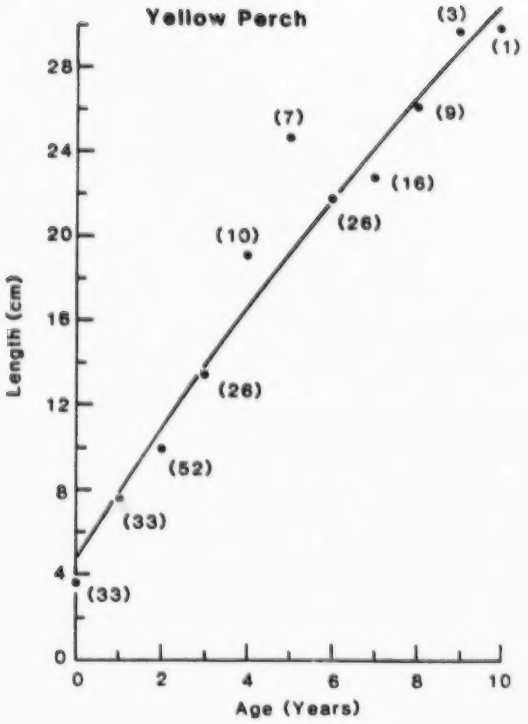

Fig. 24. Length-age curve for yellow perch collected from Mill Lake. Line is fitted by eye.

Appendix 1. Age-size data for brook trout (Salvelinus fontinalis)

Date	Age	$\bar{L}$ (cm)	SD	$\bar{Wt}$ (g)	SD	n
			Chisholm Lake			
15.06.78		4.5	-	0.7	-	1
06.07.78	1	14.3	-	63.4	-	1
	2	20.3	-		-	1
	3	24.1	1.64	114.0	-	3
	4	28.0	3.38	204.6	-	5
			Creasey lake			
20.06.78	1	16.2	1.06	52.4	11.10	2
	2	17.8	0.78	74.4	5.07	2
	3	22.5		150.6		6
22.09.78	0	10.0	1.27	5.3	5.35	2
	1	17.0	-	7.1	-	1
23.09.78	2	25.4	2.54	193.4	62.23	11
			Kerr Lake			
20.06.78	3	31.6		422.5	-	2
12.08.78	2	17.7	-	65.0	-	1
	3	24.1	-	188.5	-	1
			Mill Lake			
14.06.78	3	26.4		331.8		5
26.09.78	1	11.7	-	14.1	-	1
	2	23.0	1.84	134.9	40.35	4
	3	27.8	0.35	247.6	4.74	2
			Mosquito Lake			
15.06.78	1	10.8	-	1.6	-	1
15.08.78	1	15.2	1.39	44.8	14.59	11
	2	18.7	2.52	91.4	46.37	9
	3	30.0	2.97	339.9	96.80	6
27.09.78	2	18.2	0.14	66.4	4.55	2
			Stein Lake			
14.06.78	3	30.0	-	417.8	-	1
09.08.78	3	36.9	-	782.6	-	3

Appendix 2. Age-size data for lake chub (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	N
				Bolton Lake				
13.06.78	1	12.3			16.0			1
09.08.78	0	3.8			0.6			1
10.08.78	2	11.7			16.6			1
				Kerr Lake				
12.06.78	1	8.3			5.0			1
				Mill Lake				
14.06.78	2	11.6			20.8			1
16.08.78	1	9.8			11.0			1
	2	10.9			16.2			1
26.09.78	2	10.2		9.9-10.8	13.1		12.2-15.5	4
	1	10.6		10.1-11.3	13.1		12.2-16.0	4
				Mosquito Lake				
16.06.78	2	10.4		10.1-10.6	15.4		14.4-16.8	4
	3	11.5			20.4			2
15.08.78	1	10.0			12.2			1
27.09.78	0	9.7			13.4			1
	1	10.2		10.0-10.3	14.6		13.7-15.4	1
	2	11.4			21.6			1

Appendix 3. Age-size data for golden shiners (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	N
				Bolton Lake				
09.08.78	0	5.9	-	-	2.3	-	-	1
				Mill Lake				
16.08.78	2	10.3	-	-	16.1	-	-	1
26.09.78	2	10.0	0.28	-	11.7	1.36	-	2
	3	13.1	-	-	25.7	-	-	1
				Mud Lake				
06.06.78	2	10.5	0.90	-	15.0	4.78	-	413
	3	12.5	1.81	-	29.8	13.82	-	96
	4	14.3	1.01	-	47.5	11.97	-	5
10.08.78	1	9.8	-	-	10.8	-	-	1
	2	12.1	1.73	-	24.4	10.79	-	9
	3	14.4	0.90	-	43.1	8.5	-	11
	4	14.8	1.36	-	51.1	16.66	-	3
29.09.78	2	11.1	1.54	-	19.4	9.37	-	13
	3	13.6	0.89	-	34.4	6.56	-	64
	4	15.0	1.52	-	48.1	15.51	-	5
	5	17.4			76.30			1

Appendix 4. Age-size data for white suckers (Catostomus commersoni).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	N
				Bolton Lake				
12.06.78	1	6.5	-	-	3.1	-	-	1
	1	7.6	1.58	-	5.7	4.51	-	33
13.09.78	3	22.1	0.65	-	129.3	14.54	-	4
	4	23.6	-	-	159.3	-	-	1
	5	28.8	28.0-29.5	-	284.2	33.54	-	2
	6	28.3	-	-	277.5	-	-	1
09.08.78	0	4.2	0.56	-	0.95	0.56	-	2
	1	8.9	0.73	-	8.72	2.12	-	58
	1	10.2	0.13	-	12.1	1.15	-	17
	1	10.9	0.30	-	15.3	1.28	-	10
	1	11.8	-	-	20.0	-	-	1
10.08.78	3	22.0	-	-	138.8	-	-	1
	5	30.2	-	-	338.0	-	-	1
27.09.78	2	23.3	3.12	-	160.9	56.25	-	3
	3	28.1	-	-	286.3	-	-	1
				Kerr Lake				
20.06.78	4	25.5	-	-	235.2	-	-	1
09.08.78	0	2.7	-	-	0.2	-	-	1
23.09.78	1	10.4	0.87	-	14.1	3.13	-	4
	2	16.0	2.14	-	53.2	22.52	-	5
	3	20.3	-	-	101.1	-	-	1
				Mill Lake				
13.06.78	1	7.8	0.25	-	5.1	0.44	-	4
14.06.78	2	15.2	2.14	-	45.2	-	-	1
	3	20.3	2.14	-	113.8	28.79	-	7
	3	22.4	0.95	-	144.3	18.82	-	7
	6	33.1	-	-	499.6	9.01	-	1
	7	33.6	-	-	512.3	-	-	1
10.08.78	0	4.4	0.36	-	1.0	0.24	-	13
	0	5.2	0.30	-	1.7	0.31	-	34
16.08.78	2	18.4	-	-	75.6	-	-	1
	3	23.6	1.56	-	167.3	31.18	-	21
	4	27.6	-	-	-	-	-	2
	5	29.2	1.50	-	-	44.80	-	4
	6	31.8	-	-	389.4	-	-	1
	7	32.8	-	-	402.2	-	-	1
26.09.78	1	10.6	-	-	14.4	-	-	1
	2	20.2	1.52	-	95.7	21.22	-	12
	3	24.9	1.24	-	175.8	24.53	-	22
	4	25.7	1.98	-	209.1	62.33	-	2
	6	30.5	-	-	367.7	-	-	1

Appendix 4. continued

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Mosquito Lake				
16.06.78	3	20.4	1.08	-	114.2	8.94	-	3
	4	25.7	2.26	-	242.8	77.2	-	2
15.08.78	2	17.9	3.64	-	90.9	64.26	-	12
	3	23.2	3.01	-	177.8	71.98	-	22
	4	26.8	6.15	-	272.8	-	-	2
27.09.78	2	20.0	1.07	-	125.2	19.14	-	2
	3	23.2	2.33	-	163.1	56.3	-	6
	4	28.2	-	-	381.8	-	-	1
				Mud Lake				
06.06.78	2	16.6	-	-	52.0	-	-	7
	3	25.3	4.06	-	226.2	68.13	-	3
	4	23.7	6.78	-	175.5	-	-	1
10.08.78	2	22.8	2.62	-	170.3	54.90	-	5
29.09.78	1	15.5	2.60	-	52.0	21.93	-	4
	2	20.5	0.46	-	106.0	11.02	-	6
	3	23.9	1.70	-	181.7	43.32	-	21
	4	24.9	1.60	-	202.7	38.50	-	10
	5	27.1	0.36	-	272.9	32.64	-	3
				Robin Hood Lake				
15.06.78	5	21.2	-	-	129.3	-	-	1
	5	24.8	4.16	-	200.8	96.68	-	4
14.08.78	0	3.1	-	-	0.2	-	-	1
	1	12.5	-	-	25.4	9.60	-	1
	2	10.9	-	-	16.1	-	-	1
15.08.78	2	15.8	0.45	-	53.4	4.02	-	7
	3	21.6	1.14	-	128.0	18.27	-	4
	5	22.7	-	-	139.9	-	-	1
	5	26.8	0.44	-	261.9	17.48	-	3
26.09.78	2	14.0	3.09	-	36.6	-	-	1
	3	20.2	1.22	-	98.1	-	-	4
	4	25.2	-	-	191.4	-	-	4
	5	26.4	-	-	233.5	-	-	1

Appendix 5. Age-size data for brown bullhead (aged from otoliths).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Mill Lake				
16.08.78	3	18.9	0.99	-	99.0	7.00	-	2
	3	20.9	-	-	136.6	-	-	2
	3	19.4	-	-	116.7	-	-	1
26.09.78	2	18.0	2.19	-	82.7	36.97	-	2
				Mud Lake				
06.06.78	1	8.5	-	-	8.3	-	-	1
	2	16.2	-	-	72.5	-	-	8
	3	17.1	-	-	83.1	-	-	18
	4	20.3	-	-	110.4	-	-	15
	5	21.6	-	-	144.6	-	-	8
10.08.78	1	11.4	-	-	21.4	-	-	1
	2	15.4	-	-	55.4	-	-	6
	3	18.5	-	-	82.0	-	-	1
	4	24.4	-	-	192.1	-	-	1

Appendix 6a. Age-size data for banded killifish (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Bolton Lake				
12.06.78	2	7.3	0.38	-	3.9	0.68	-	5
	3	9.0	1.34	-	7.5	3.82	-	2
09.08.78	0	3.0	0.35	-	0.23	0.18	-	118
27.09.78	0	4.2	0.58	-	0.6	0.24	-	57
	1	7.6	0	-	3.5	0.04	-	2
				Creasey Lake				
12.06.78		2.9	0.21	-	0.2	0.04	-	89
		3.6	0.34	-	0.35	0.11	-	175
		5.8	0.64	-	1.7	0.53	-	237
		6.7	0.37	-	2.7	0.59	-	103
	3	7.9	0.28	-	4.9	0.59	-	6
09.08.78	0	3.8	1.30	-	0.7	0.60	-	428
	1	6.13	0.54	-	2.3	0.75	-	555
	2	6.8	0.30	-	3.2	0.20	-	5
22.09.78	0	2.4	0.57	-	0.2	0.10	-	137
	1	4.0	-	-	0.6	-	-	1
	2	7.0	-	-	3.8	-	-	1
				Kerr Lake				
09.08.78	1	6.1	-	-	2.4	-	-	1
22.09.78	0	2.8	0.81	-	0.3	0.22	-	6
	2	7.7	-	-	5.0	-	-	1
				Mill Lake				
13.06.78	2	6.1	2.26	-	2.0	2.05	-	2
	3	9.0	0.07	-	6.0	0.85	-	2
25.09.78	0	3.5	-	-	0.4	-	-	1
				Mosquito Lake				
26.09.78	0	2.1	0.46	-	0.1	0.05	-	3
				Robin Hood Lake				
15.06.78	1	5.8	0.98	-	1.6	0.54		10
	2	7.5	0.36	-	3.5	0.51		10
14.08.78	0	2.1	0.51	-	0.1	0.10	-	496
	1	5.5	0.50	-	1.5	0.43	-	20
	2	7.0	0.45	-	3.3	1.07	-	28
	2	7.8	0.47	-	4.4	0.90	-	23
				Stein Lake				
25.09.78	0	2.4	0.60	-	0.2	0.13	-	153

Appendix 6a. continued

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Wheaton Lake				
12.06.78	0	3.0	0.42	-	0.2	0.07	-	2
	1	4.6	0.43	-	0.7	0.20	-	12
	2	8.12	0.90	-	4.4	1.80	-	109
09.08.78	0	2.5	0.40	-	0.12	0.07	-	592
	1	6.1	0.30	-	2.0	0.28	-	12
	2	7.4	0.59	-	3.6	0.96	-	10
22.09.78	0	3.7	0.59	-	0.44	0.18	-	363
	0 or 1	4.8	0.46	-	1.0	0.48	-	48

Appendix 6b. Sizes of threespine sticklebacks (unaged).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Mill Lake				
13.06.78	-	5.4	0.54	-	1.5	0.42	-	16
10.08.78	-	3.9	0.30	-	0.5	0.14	-	78

Appendix 7. Age-size data for white perch (aged from otoliths).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Bolton Lake				
12.06.78	5	16.7	-	-	65.5	-	-	1
	6	17.5	-	-	68.8	-	-	6
	7	19.8	-	-	95.6	-	-	2
	8	19.8	-	-	95.0	-	-	4
	9	19.9	-	-	98.9	-	-	3
	10	22.0	-	-	119.1	-	-	2
	11	21.1	-	-	124.9	-	-	1
	12	20.8	-	-	113.8	-	-	2
13.06.78	2	12.7	-	-	22.7	-	-	3
	3	12.9	-	-	25.2	-	-	11
	4	13.1	-	-	26.2	-	-	9
	5	16.4	-	-	58.3	-	-	10
	6	17.8	-	-	75.7	-	-	9
	7	18.6	-	-	89.7	-	-	12
	8	19.1	-	-	94.9	-	-	12
	9	20.3	-	-	120.5	-	-	16
	10	20.6	-	-	122.8	-	-	16
	11	21.1	-	-	129.8	-	-	11
	12	-	-	-	-	-	-	0
	13	26.0	-	-	266.3	-	-	1
	14	-	-	-	-	-	-	0
	15	22.4	-	-	174.2	-	-	2
	16	-	-	-	-	-	-	0
	17	-	-	-	-	-	-	0
	18	29.1	-	-	444.8	-	-	1
09.08.78	0	2.0	-	-	0.11	-	-	22
10.08.78	2	15.0	-	-	43.3	-	-	3
	3	14.5	-	-	40.3	-	-	1
	4	17.3	-	-	68.9	-	-	3
	5	17.8	-	-	80.0	-	-	2
	6	19.1	-	-	99.8	-	-	5
	7	23.0	-	-	185.2	-	-	1
	10	22.4	-	-	188.0	-	-	5
	11	21.9	-	-	170.7	-	-	1
	13	22.6	-	-	180.7	-	-	1
	16	25.8	-	-	262.4	-	-	1
29.09.78	3	15.0	-	-	45.7	-	-	5
	4	16.2	-	-	57.9	-	-	1
	5	18.6	-	-	90.2	-	-	5
	6	21.4	-	-	122.0	-	-	2
	7	21.2	-	-	139.4	-	-	2
	8	20.5	-	-	132.0	-	-	2
	9	21.8	-	-	159.1	-	-	5
	10	21.9	-	-	160.0	-	-	4
	11	21.3	-	-	144.0	-	-	1

Appendix 7. continued

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Wheaton Lake				
12.06.78	1	6.6	0.70	-	3.0	0.94	-	12
	2	7.6	2.33	-	6.1	5.49	-	12
	3	12.1	1.65	-	19.6	6.53	-	3
	12	19.2	-	-	60.4	-	-	1
21.06.78	1	10.9	0.66	-	14.5	2.76	-	3
	2	13.1	1.14	-	32.1	9.45	-	5
	3	14.6	0.89	-	45.8	8.68	-	7
	4	16.5	0.54	-	68.1	11.16	-	12
	5	17.2	1.06	-	79.7	17.16	-	13
	6	18.0	0.94	-	90.8	13.15	-	23
	7	18.6	1.42	-	108.9	28.03	-	11
	8	20.1	2.23	-	135.3	46.56	-	27
	9	19.4	0.88	-	118.2	17.68	-	21
	10	19.8	1.48	-	125.1	26.64	-	4
	11	21.2	1.27	-	143.3	26.40	-	2
	12	21.1	0.71	-	142.5	18.34	-	5
	13	20.0	0.86	-	122.2	18.53	-	9
	14	22.0	5.75	-	206.8	-	-	3
	15	20.1	-	-	110.2	-	-	1
09.08.78	0	4.7	-	-	1.4	-	-	1
09.08.78	2	15.0	-	-	59.7	-	-	1
	4	16.9	-	-	66.0	-	-	1
	5	17.7	0.48	-	85.3	8.01	-	11
	6	18.9	0.75	-	100.7	11.97	-	27
	7	19.2	0.85	-	108.4	16.22	-	25
	8	19.9	1.05	-	115.9	19.22	-	22
	9	20.6	1.27	-	132.6	25.83	-	26
	10	22.0	2.53	-	169.6	82.16	-	11
	11	21.4	-	-	134.33	-	-	1
	12	21.6	0.99	-	144.6	21.80	-	6
	13	23.4	4.66	-	230.28	-	-	4
	14	22.5	1.68	-	170.5	45.63	-	6
	15	22.8	-	-	191.9	-	-	1
27.09.78	2	12.1	1.56	-	13.6	8.25	-	18
	3	14.4	1.25	-	41.7	12.34	-	27
	4	18.6	0.31	-	100.0	4.18	-	6
	5	19.3	0.41	-	108.5	5.94	-	12
	6	19.7	1.12	-	115.7	20.96	-	13
	7	19.7	0.91	-	119.0	14.15	-	13
	8	20.3	0.86	-	121.8	16.91	-	8
	9	21.5	0.17	-	149.2	5.89	-	3
	10	22.0	2.32	-	161.4	64.10	-	6
	11	22.8	2.40	-	184.9	70.98	-	2
	12	22.7	1.28	-	163.7	30.46	-	3
	13	23.0	1.19	-	193.8	35.32	-	4
	14	22.2	1.42	-	169.5	32.35	-	3
	15	22.1	-	-	130.4	-	-	1

Appendix 8. Age-size data for pumpkinseeds (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Kerr Lake				
22.09.78	0	2.5	-	-	0.3	-	-	1
				Mill Lake				
14.06.78	2	12.5	-	-	41.9	-	-	1
				Mud Lake				
13.06.78	1	6.4	-	-	5.4	-	-	1
	2	8.8	0.95	-	14.7	3.96	-	7
	3	13.6	1.06	-	61.4	15.68	-	2
				Robin Hood Lake				
14.08.78	0	1.6	0.25	-	0.1	0.02	-	28
	2	8.1	-	-	9.7	-	-	1

Appendix 9. Age-size data for smallmouth bass (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Bolton Lake				
09.08.78	0	3.7	-	-	0.79	-	-	1
10.08.78	1	13.8	0.20	-	39.1	2.82	-	3
	3	26.5	-	-	324.5	-	-	1
	4	30.0	-	-	450.2	-	-	1
27.09.78	1	14.2	-	-	41.4	-	-	1
				Mill Lake				
13.06.78	0	4.0	-	-	0.6	-	-	1
10.08.78	0	4.7	0.69	-	1.6	0.62	-	9
25.09.78	0	5.8	0.96	-	2.9	1.36	-	18
				Mud Lake				
06.06.78	7	33.2	-	-	667.4	-	-	1
	8	33.9	0.21	-	661.3	36.20	-	3
	9	34.2	-	-	630.3	-	-	1
	8	37.6	-	-	861.5	-	-	1
10.08.78	0	5.0	0.60	-	1.84	0.70	-	152
	2	20.8	-	-	146.1	-	-	1
	3	23.1	-	-	195.7	-	-	1
	4	27.8	-	-	363.5	-	-	1
	5	30.7	-	-	447.9	-	-	1
	7	33.7	-	-	579.2	-	-	1
	8	37.0	-	-	942.5	-	-	1
				Stein Lake				
14.06.78	4	21.2	-	-	145.8	-	-	1
	6	31.1	-	-	551.1	-	-	1
09.08.78	3	18.3	-	-	99.4	-	-	1
				Wheaton Lake				
21.06.78	6	28.3	-	-	343.1	-	-	1
	8	38.0	-	-	793.9	-	-	1
09.08.78	8	41.0	-	-	1060.5	-	-	1
27.09.78	2	23.4	-	-	240.1	-	-	1

Appendix 10. Age-size data for yellow perch (aged from scales).

Date	Age	$\bar{L}$ (cm)	SD	Range	$\bar{Wt}$ (g)	SD	Range	n
				Bolton Lake				
12.06.78	2	9.3	-	-	8.2	-	-	1
09.08.78	0	4.4	0.50	-	1.06	0.31	-	25
	1	7.2	1.33	-	4.4	1.97	-	9
	2	10.6	-	-	12.5	-	-	1
27.08.78	9	5.7	0.37	-	1.81	0.37	-	58
				Mill Lake				
13.06.78	1	6.2	0.41	-	2.5	0.55	-	6
	2	9.5	1.83	-	8.2	3.14	-	1
14.06.78	2	10.1	1.20	-	15.0	6.68	-	14
	3	14.8	2.57	-	50.8	29.32	-	11
	4	20.0	3.35	-	125.6	55.87	-	5
	5	24.0	15.13	-	203.3	23.33	-	2
	6	25.9	2.29	-	263.9	35.81	-	3
	7	29.1	-	-	386.5	-	-	1
10.08.78	0	4.4	0.57	-	1.12	0.45	-	12
	1	7.1	0.62	-	4.4	0.89	-	3
	2	9.0	-	-	7.2	-	-	1
16.08.78	2	9.6	-	-	10.5	-	-	1
	3	11.0	1.08	-	16.2	6.77	-	9
	4	18.9	2.58	-	97.3	37.01	-	3
	5	22.6	0.64	-	164.3	21.94	-	2
	6	24.7	0.71	-	228.6	51.20	-	2
	7	28.0	-	-	301.2	-	-	1
25.09.78	0	6.3	-	-	3.2	-	-	21
	1	8.3	-	-	7.2	-	-	40
	2	11.1	-	-	16.2	-	-	17
26.09.78	2	10.8	0.14	-	12.1	1.02	-	2
	3	13.7	1.17	-	26.3	7.60	-	5
	4	17.4	1.91	-	57.5	22.56	-	2
	5	19.9	1.79	-	90.8	35.16	-	3
	6	20.9	1.23	-	112.0	25.99	-	21
	7	2[illegible] 0	1.93	-	131.6	44.10	-	14
	8	26.2	2.05	-	243.6	61.33	-	9
	9	29.8	0.90	-	371.8	19.95	-	3
	10	30.0	-	-	386.1	-	-	1

POOR

QUALITY

ORIGINAL